

Description

This invention relates to a switched optical network for connecting signals from any one of a plurality of transmitter stations with any one of a plurality of receiver stations. It is of particular, but not exclusive, application to telecommunications networks.

It is generally desirable to have a switched network which is non-blocking for connecting transmitter stations with receiver stations, that is, one in which any transmitter station can be connected to any free receiver station at any time.

A space switching circuit employing a single stage of crosspoints requires a number of switches equal to the product of the number of transmitter stations, T, and receiver stations, R. This arrangement becomes increasingly impracticable as the number of stations increases because of the need to incorporate a rapidly increasing number of switches. One approach to solving this problem is to use a multistage switching network which can be made non-blocking for a given number of stations by means of specific interconnections. Although reducing the number of switches needed from T.R, disadvantages of this approach are that it is not easily expandable and the increasing complexity of the control system needed to control the switches. If only a few extra stations are to be added to such a network, the number of additional switches can be kept to a minimum only at the expense of redesigning and reconfiguring the interconnections between switches. If this is to be avoided the existing stages must essentially be duplicated which while reducing the redesign necessary has more switching capacity than may be required.

Another method of providing a non-blocking switched network is to multiplex the signals from the transmitter stations and broadcast the multiplex to the receiver stations and demultiplex the required channel. Various multiplexing schemes have been employed, for example pulse position coding, time domain multiplexing and frequency or wavelength multiplexing. Wavelength multiplexing in optical networks has been recognised as providing, in principle, the means of multiplexing many thousands of optical signals but in practice there are severe obstacles to be overcome in providing an optical network employing a multiplex of such a large number of frequencies. In an optical fibre network the wavelengths need to be closely spaced to fall within the useable wavelength window of the fibre and the optical sources of the many wavelengths have to be extremely accurately tuned. Similarly the optical detectors of the receivers need to be very accurately tunable to receive only one wavelength with minimum crosstalk from adjacent wavelengths.

It is an object of the present invention to provide a switched optical network which can handle large numbers of signal channels more readily than hitherto possible. It is a further object of the present invention to provide a switched optical network that can be readily expanded to accommodate a relative few extra stations. In EP-A-223258 there is shown apparatus for interconnecting input and output via optically multiplexed signals in which selection relies on changing wavelengths of signals.

Accordingly there is provided a switched optical network for connecting signals from any one of a plurality of transmitter stations with any one of a plurality of receiver stations comprising:-

at least two optical multiplexing means each responsive to signals from two or more transmitter stations to provide an optical multiplex corresponding to the transmitter station signals;

a plurality of demultiplexing means each responsive to an optical multiplex and a selection signal to output one transmitter station signal to the corresponding receiver station; and

an optical switch means responsive to switch signals to optically couple any one of the optical multiplexes to any one of the demultiplexing means.

The signal from each transmitter station is converted into an optical signal forming part of one of the optical multiplexes coupled to the optical switch means. Because the switch means can optically couple any of the multiplexes to the demultiplexer associated with a chosen receiver station, any transmitter station can be switched to any receiver station. Thus, if, for example, 400 transmitters were to be connected to 400 receivers the respective optical signals could be multiplexed into groups of twenty multiplexes thereby forming a non-blocking network with reduced complexity to a similar network relying solely on multiplexing all the optical signals onto one multiplex or by employing a 400 by 400 optical switch.

Any multiplexing method producing an optical multiplex may be used with the network of the present invention. Preferably wavelength multiplexing is used as this technique provides the greatest scope for wideband communication to which optical networks are of particular use. In this case each multiplexing means may include a plurality of optical sources for providing optical power at two or more wavelengths, a plurality of modulators each optically coupled to one of the optical sources and responsive to a signal from a transmitter station to provide an optical signal representative of that signal, and a plurality optical combiners for combining the optical signals to form the optical multiplex.

Generally, more than one transmitter station

signal will modulate an optical carrier of a given wavelength. A separate optical source may be provided for each such modulator or, alternatively, each optical source may provide optical power for more than one modulator. Conveniently every modulator operating at a given wavelength is supplied optical power by a single optical source.

Conveniently all the modulators of the network coupled to an optical source of a given wavelength are housed in a respective distinct unit. Such a unit may have one optical input, for example an optical fibre, for connection to an optical source with an internal optical splitter for splitting the optical power from the optical source to each modulator in the unit. With such an arrangement, an optical network according to the invention can be expanded to accommodate extra transmitters in stages of one unit by providing an additional optical source operating at a wavelength different from the others and coupling the extra unit's modulator outputs to the existing multiplexes.

Another convenient arrangement is to house all the optical modulators of the network whose optical outputs form part of the same multiplex in a respective, distinct unit. In this case the multiplexing means may conveniently include an optical coupler within the housing having an output for connection to the switching means, the modulators each being connected to an optical source of a different wavelength. Such an optical network can also be conveniently expanded in stages to accommodate extra transmitters by optically coupling the additional modulators to the respective optical sources and optically connecting the additional multiplex output to the switching means.

If desired, units of different size can be provided in either of the above schemes to provide more flexible growth stages.

The control means will have to be modified on expansion of the network to permit the new interconnections. The switching means may be provided with sufficient optical waveguides for anticipated expansion which could then be achieved readily by splicing each new modulator group to an unused waveguide.

If the size of the network is known beforehand the number of multiplexes and the number of optical signals per multiplex can be designed to optimise costs by having regard to the relative costs of providing larger and smaller multiplexers and switching means.

The switching means may comprise a parallel bus of optical fibres optically coupled to the multiplexers, each carrying one optical multiplex to a single respective optical space switch, each demultiplexer of the network being connected to one output of every optical switch. That is, each optical space switch is arranged to connect the respective

multiplex to any number of the demultiplexers to which it is connected.

Alternatively, the switch means may have a plurality of optical space switches each having a plurality of inputs equal in number to the number of multiplexes. In this case each multiplex is optically coupled to an input of every optical space switch, and every demultiplexer is coupled to one output of just one of the optical space switches.

The demultiplexer must be able to extract the required transmitter signal from the multiplex for forward transmission to the corresponding receiver station. In the case of time domain multiplexing this can be achieved by optical demultiplexing methods before the optical signals impinge on an optical detector or by electronic demultiplexing after optical detection. In the case of wavelength multiplexing a tunable optical filter can be used to select the required optical signal from the multiplex.

Where a particular application of the present invention has the optical detectors of the demultiplexers sufficiently close to the optical modulators of the multiplexers, a coherent optical detector may be used employing homodyne or heterodyne detection. There may then be provided a selection means optically coupled to the sources of optical power which is responsive to a selection signal from the control means to connect an optical source with a selected output from an optical space switch. For homodyne detection the optical sources are combined unshifted in wavelength. For heterodyne detection the optical sources are combined with a selected output from the switch means after being frequency shifted a predetermined amount.

It is anticipated that an optical communication network according to the present invention providing interconnections between up to 10,000 transmitter and 10,000 receiver stations can be realised with present technology whilst having a structure of design which allows efficient and economic growth to be achieved in relatively small, incremental steps. When a network utilise wavelength multiplexing, the bandwidth for each multiplex is limited only by the optoelectronic interface and therefore transmission at G bit rates is expected to be possible.

It will be appreciated by those working in the field of the invention that the control means required for the network can be particularly simple and that the present invention is applicable to both highly centralised and partially distributed control schemes and is not dependent on its operation on the actual control scheme or method employed. It is envisaged that the control means will be electronic and computer controlled but optical control means may be a possibility for future systems.

The present invention is applicable to switched networks other than for use for telecommunications applications. It may be used in interconnecting

devices on a multiple processor, shared memory computers or other parallel processing schemes, for example.

Where a large number of multiplexes are employed it may be necessary to use in-line broadband laser amplifiers within the switching means to amplify the multiplexes due to splitting losses involved in optically splitting each multiplex to several optical space switches.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which -

Figure 1 is a schematic diagram of a switched optical network employing wavelength modulation;

Figure 2 is a schematic diagram of one unit of optical modulators of the network of Figure 1;

Figure 3 is a schematic diagram of an alternative grouping of modulators for the network of Figure 1;

Figure 4 is a schematic diagram of a combined optical space switch applicable to coherent receivers; and

Figure 5 is a schematic diagram of an optical network using non-wavelength multiplexing.

Referring to Figures 1 and 2, a switched optical network has one hundred units U_1 to U_{100} (only four shown for clarity) each housing one hundred of ten thousand optical modulators M_1 to $M_{10,000}$ (see Fig 2) each of which is electrically connectable to a distinct transmitter station (one shown) via one of electrical connections T_1 to $T_{10,000}$ (only three per unit shown for clarity). The transmitter stations may be sources telephone or television signals for example. Each modulator M of a given unit is optically coupled to one of optical sources O_1 to O_{100} each emitting a distinct wavelength (λ_1 to λ_{100}) (only four shown for clarity). The optical outputs from the modulators M within each unit U are combined by means of optical couplers C_1 to C_{100} , respectively, to form one hundred optical wavelength multiplexes each optically coupled into one of optical fibres 2 which are conveniently represented as an optical data bus 4. The optical sources O , modulators M and optical couplers C are elements of the multiplexing means of the network.

In the arrangement of Figure 1, the optical power for every modulator M operating at a given frequency is provided by one corresponding optical source O whose output is split 100 ways by a corresponding one of the optical splitter S_1 to S_{100} , one of the splitter outputs being optically coupled to one modulator M on each unit U .

The optical sources O may, for example, be laser diodes or other sources of coherent optical radiation. In the arrangement of Figure 1 it may be necessary to use a central referencing system (not

shown) to maintain the required wavelength separation. A range of techniques have been proposed to achieve this in a paper entitled "Evolutionary wavelength division multiplexed schemes for broadband networks", by G.R. Hill, D.W. Smith, R.A. Lobbett, T.G. Hodgkinson and R.P. Webb, OFC 87, Reno 1987. If the optical power required by the modulators is more than one optical source can provide, two or more optical sources can be provided at each wavelength with a corresponding lower optical split and with each optical source providing optical power to a subset of the units U . A smaller network will require fewer wavelengths in which case it may be possible to dispense with a referencing system, and lasers would be chosen which are separated in wavelength by several nm and operated with individual wavelength stabilisation. Other optical sources may be useable, eg. light emitting diodes with suitable optical filtering.

The modulators may be phase, frequency or amplitude modulators which in practice may be for example lithium niobate modulators. The modulators are grouped in units for convenience which in practice may incorporate any number of modulators. If the number of modulators per unit is less than the number of available frequencies, two or more units will have their outputs combined to form a complete multiplex. The number of distinct frequencies determines the maximum number of channels on each multiplex.

The multiplexed signals from the multiplexing means are each coupled via the optical fibres 2 to optical space switches SW_1 to SW_{100} (only three shown for clarity) each having one hundred inputs (not shown). One input of each switch SW is optically coupled to one multiplexer. Each switch SW has one hundred outputs to provide in total outputs OP to $OP_{10,000}$ (only three shown for SW_1 for clarity), each output OP being connected to a respective heterodyne receiver R_1 to $R_{10,000}$, constituting the demultiplexing means, of an associated receiver station.

A controller 6 monitors requests for connections and supplies switch signals on a switch bus 8 and selection signals on a selection bus 10.

The optical space switches are configured to be able to switch any input to any one or more outputs OP simultaneously in response to switch signals received from the controller 6 via the switch bus 8. Thus a signal from any transmitter station can be switched to any receiver station by controlling the appropriate optical space switch to switch the multiplex containing the corresponding optical signal from the modulator M corresponding to that transmitter station to the desired demultiplexer of a receiver station and selecting the appropriate signal from that multiplex in response to the selection signal from the controller 6.

Suitable optical space switches are LCD type devices, combinations of optical and mechanical switches and D fibre devices or Lithium niobate planar waveguide switches, for example where configurable in a broadcast (i.e. one to many) arrangement.

In the arrangement of Figure 1, the receiver stations are associated with heterodyne optical receivers R. The desired channel from the multiplex switched to the receiver R is obtained by combining the multiplex with optical power derived from that one of frequency shifters 12 coupled to the optical sources O which in turn is coupled to the modulator M of the transmitter station to be received. The frequency shifted optical power is switched by means of optical space switches SW' to one of optical couplers 14 (three shown). The frequency shifters may be acoustic-optic devices or electrooptic devices whose operation are based on the serodyne approach for example.

If homodyne receivers are used the frequency shifters would be omitted.

Alternatively filters located in front of the optical detector of the demultiplexer tunable under the control of the controller 6 could be used to select the required channel from the multiplex.

Other arrangements of optical space switches which allow any multiplex to be switched to any receiver can be employed, for example optical spaces switch could be used which have one input for connection to a respective multiplex and have many outputs, with one output coupled to each demultiplexer. This may have application for smaller networks where the simplicity of the switch architecture may offset the necessity to provide multiple coupling to each demultiplexer.

The hetero/homodyne detection methods discussed above have particular applicability to networks where the multiplexers and demultiplexers are located closely together, for example in connecting components of a computer system.

Referring now to Figure 3 an alternative grouping of modulators M in units to that shown in Figure 1 is shown. All those modulators M of the network coupled to an optical source O of a given wavelength are housed in a distinct unit, the multiplexes being formed by combining one output of each modulator with one output from each of the other units. When the network has the same number of optical space switches as multiplexes (as in the Figure 1 embodiment), the optical combiners may conveniently be formed by star couplers with each output of each star coupler being optically coupled to a different one of the optical space switches SW.

Referring now to Figure 4, an optical space switch 14 is shown which combines the action of the combination of switches SW and SW' of Figure

1 to switch both a frequency shifted optical source and a multiplex to a chosen coherent receiver in response to signals from the controller 6.

Referring now to Figure 5, a switched optical network is shown suitable for use with multiplexing methods other than wavelength multiplexing. In this instance the controller 6 directs the required multiplex to the required demultiplexer in the same way as described earlier by controlling the appropriate optical space switch SW. The controller 6 sends the selection signals to the appropriate demultiplexer via bus 10 to specify which of the multiplexed channels is to be demultiplexed for onward transmission to the corresponding receiver receiver station. The signals from groups of transmitters may utilise pulse position coding to form the multiplexes, for example.

Alternatively, it may be possible to achieve demultiplexing of the required channel by optical means prior to applying any optical signal to an optical detector of the receiver, in which case the controller 6 will send selection signals to the appropriate optical demultiplexer.

In the embodiment of Figure 5, the multiplexes are formed by multiplexing signals from transmitter stations in the electrical domain to form an electrical multiplex which electrical multiplex is applied to an optical modulator to form the corresponding optical multiplex by multiplexers 14. Only one wavelength of optical power 16 is required but several sources may be provided if necessary.

When only one transmitter station associated with a particular multiplex is transmitting it will be understood that the corresponding signal can be regarded as being multiplexed with null signals from the other stations.

Claims

1. A switched optical network for connecting signals from any one of a plurality of transmitter stations (T_1 - T_{10000}) with any one of a plurality of receiver stations (R_1 - R_{10000}) comprising: -
 - at least two optical multiplexing means (U_1 - U_{100}) each responsive to signals from respective two or more transmitter stations and each providing an optical multiplex signal corresponding to the signals of the transmitter stations to which it is connected;
 - a plurality of demultiplexing means (14);
 - and a plurality of optical switch means (SW_1 - SW_{100});—
 characterised in that
 - the plurality of optical switch means are arranged to receive all of said optical multiplex signals and each optical switch means is connected to a respective two or more receivers, each optical switch means being controlled to

Suitable optical space switches are LCD type devices, combinations of optical and mechanical switches and D fibre devices or Lithium niobate planar waveguide switches, for example where configurable in a broadcast (i.e. one to many) arrangement.

In the arrangement of Figure 1, the receiver stations are associated with heterodyne optical receivers R. The desired channel from the multiplex switched to the receiver R is obtained by combining the multiplex with optical power derived from that one of frequency shifters 12 coupled to the optical sources O which in turn is coupled to the modulator M of the transmitter station to be received. The frequency shifted optical power is switched by means of optical space switches SW to one of optical couplers 14 (three shown). The frequency shifters may be acoustic-optic devices or electrooptic devices whose operation are based on the serodyne approach for example.

If homodyne receivers are used the frequency shifters would be omitted.

Alternatively filters located in front of the optical detector of the demultiplexer tunable under the control of the controller 6 could be used to select the required channel from the multiplex.

Other arrangements of optical space switches which allow any multiplex to be switched to any receiver can be employed, for example optical spaces switch could be used which have one input for connection to a respective multiplex and have many outputs, with one output coupled to each demultiplexer. This may have application for smaller networks where the simplicity of the switch architecture may offset the necessity to provide multiple coupling to each demultiplexer.

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Referring now to Figure 4, an optical space switch 14 is shown which combines the action of the combination of switches SW and SW_i of Figure

1 to switch both a frequency shifted optical source and a multiplex to a chosen coherent receiver in response to signals from the controller 6.

Referring now to Figure 5, a switched optical network is shown suitable for use with multiplexing methods other than wavelength multiplexing. In this instance the controller 6 directs the required multiplex to the required demultiplexer in the same way as described earlier by controlling the appropriate optical space switch SW. The controller 6 sends the selection signals to the appropriate demultiplexer via bus 10 to specify which of the multiplexed channels is to be demultiplexed for onward transmission to the corresponding receiver receiver station. The signals from groups of transmitters may utilise pulse position coding to form the multiplexes, for example.

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When only one transmitter station associated with a particular multiplex is transmitting it will be understood that the corresponding signal can be regarded as being multiplexed with null signals from the other stations.

Claims

1. A switched optical network for connecting signals from any one of a plurality of transmitter stations (T_1 - T_{10000}) with any one of a plurality of receiver stations (R_1 - R_{10000}) comprising: -
 - at least two optical multiplexing means (U_1 - U_{100}) each responsive to signals from respective two or more transmitter stations and each providing an optical multiplex signal corresponding to the signals of the transmitter stations to which it is connected;
 - a plurality of demultiplexing means (14);
 - and a plurality of optical switch means (SW_1 - SW_{100});
 - characterised in that
 - the plurality of optical switch means are arranged to receive all of said optical multiplex signals and each optical switch means is connected to a respective two or more receivers, each optical switch means being controlled to



switch selected optical multiplex signals to selected receivers,

a respective demultiplexer means being connected to each output (OP) of each optical switch means, each demultiplexer means corresponding to a unique receiver and being controlled to demultiplex the multiplexed signal selected by the optical switch means and to pass a selected signal from the demultiplexed signal to the receiver.

2. A network as claimed in claim 1 characterised in that each multiplexing means includes a plurality of optical sources ($O_1 - O_{100}$) for providing optical power at two or more wavelengths, a plurality of modulators ($M_1 - M_{100}$) each optically coupled to a respective one of the optical sources and responsive to a signal from a respective transmitter station to provide an optical signal representative of that transmitter station signal, and optical combiner means (C1) for combining the optical signals to form the optical multiplex.
3. A network as claimed in claim 1 characterised in that there is only one optical source of optical power at each wavelength.
4. A network as claimed in either one of claim 2 and 3 characterised in that the wavelengths of the optical sources are fixed by a central wavelength referencing means (12).
5. A network as claimed in any one of claims 2 to 4 characterised in that the optical sources are lasers.
6. A network as claimed in any one of claims 2 to 5 characterised in that all the modulators of the network coupled to an optical source of a given wavelength are housed in a respective, distinct unit ($U_1 - U_{100}$).
7. A network as claimed in claim 6 characterised in that the number of modulators in each unit is equal to the number of optical multiplex signals provided by that unit.
8. A network as claimed in any one of claims 2 to 5 characterised in that all the modulators of the network whose optical outputs form part of the same multiplexing means are housed in a respective, distinct unit.
9. A network as claimed in claim 8 characterised in that the number of units is equal to the number of distinct wavelengths from the optical sources.

10. A network as claimed in any one of claims 6 to 9 characterised in that the modulators of each unit are formed on a single lithium niobate substrate.

11. A network as claimed in any preceding claim characterised in that the optical switch means includes a plurality of optical space switches, each having one input optically coupled to a respective multiplexing means, and a plurality of outputs, a respective demultiplexer being optically coupled to each output of every optical space switch.

12. A network as claimed in any one of claims 1 to 10 characterised in that the optical switch means includes a plurality of optical space switches, each having a plurality of inputs, each multiplexing means being optically coupled to an input of every optical space switch, and each having a plurality of outputs, a respective demultiplexer being optically coupled to each output of every optical space switch.

13. A network as claimed in claim 12 characterised in that the number of outputs of each optical space switch equals the number of multiplexing means.

14. A network as claimed in claim 13 as dependent on claim 9 characterised in that each optical combiner is a star coupler having a plurality of outputs, each output being optically coupled to an input of a distinct optical space switch.

15. A network as claimed in any one of claims 1 to 14 characterised in that each demultiplexer is also coupleable to any optical source by a selection means responsive to a selection signal.

16. A network as claimed in either of claims 14 and 15, as dependent on claim 13, characterised in that the selection means comprises a plurality of secondary optical space switches equal in number to the number of optical space switches, each having a plurality of inputs equal in number to the number of distinct wavelengths of the optical sources and each input being connected to a optical source of distinct wavelength, and each having a plurality of outputs equal in number to the number of optical space switches, each output of a given secondary optical space switch being combined with a distinct output of one corresponding optical space switch.



17. A network as claimed in any one of claims 15 to 16 characterised in that each secondary optical space switch forms part of the corresponding optical space switch, each output of the optical space switch being optically coupleable simultaneously to one of the inputs connected to a multiplexing means.

18. A network as claimed in anyone of claims 15 to 16 for use with a heterodyne receiver, characterised in that the selection means includes a frequency shift means whereby each optical source is frequency shifted by a predetermined amount prior to being coupled with the output of an optical space switch.

19. A network as claimed in claim 2 characterised in that the receiver includes a tunable filter responsive to a selector signal to permit one of the wavelengths of the wavelength multiplex only to reach the optical detector of the receiver.

Patentansprüche

1. Optisches Vermittlungsnetzwerk zum Verbinden von Signalen von irgendeiner einer Vielzahl von Sendestationen ($T_1 - T_{10000}$) mit irgendeiner einer Vielzahl von Empfängerstationen ($R_1 - R_{10000}$), das umfaßt:

mindestens zwei optische Multiplexeinrichtungen ($U_1 - U_{100}$), die jeweils auf Signale von jeweiligen zwei oder mehreren Sendestationen antworten, und die jeweils ein optisches Multiplexsignal erzeugen, das den Signalen der Sendestationen entspricht, mit dem sie verbunden sind;

eine Vielzahl von Demultiplexeinrichtungen (14);

und eine Vielzahl von optischen Umschalt-einrichtungen ($SW_1 - SW_{100}$);

dadurch gekennzeichnet, daß

die Vielzahl optischer Schalteinrichtungen angeordnet ist, um alle der optischen Multiplexsignale zu empfangen, und jede optische Umschalt-einrichtung mit jeweiligen zwei oder mehreren Empfängern verbunden ist, wobei jede optische Umschalt-einrichtung gesteuert wird, um ausgewählte optische Multiplexsignale zu ausgewählten Empfängern umzuschalten,

eine jeweilige Demultiplexeinrichtung mit jedem Ausgang (OP) jeder optischen Umschalt-

einrichtung verbunden ist wobei jede Demultiplexeinrichtung einem einzigen Empfänger entspricht und gesteuert wird, um das multiplexte Signal zu demultiplexen, das durch die optische Umschalt-einrichtung ausgewählt ist und um ein ausgewähltes Signal von dem demultiplexten Signal zu dem Empfänger zu führen.

2. Netzwerk nach Anspruch 1, dadurch gekennzeichnet, daß jede Multiplexeinrichtung enthält: eine Vielzahl optischer Quellen ($O_1 - O_{100}$) zum Bereitstellen optischer Leistung bei zwei oder mehreren Wellenlängen, eine Vielzahl von Modulatoren ($M_1 - M_{100}$), von denen jeder mit einer jeweiligen der optischen Quellen optisch gekoppelt ist und auf ein Signal von einer jeweiligen Sendestation antwortet, um ein optisches Signal zu erzeugen, das jenes Sendestationssignal darstellt, und eine optische Kombiniereinrichtung (C1) zum Kombinieren der optischen Signale, um den optischen Multiplex zu bilden.

3. Netzwerk nach Anspruch 1, dadurch gekennzeichnet, daß es nur eine optische Quelle optischer Leistung bei jeder Wellenlänge gibt.

4. Netzwerk, wie es in einem der Ansprüche 2 und 3 beansprucht ist, dadurch gekennzeichnet, daß die Wellenlängen der optischen Quellen durch eine zentrale Wellenlängenbezugs-einrichtung (12) fixiert sind.

5. Netzwerk nach einem der Ansprüche 2 bis 4, dadurch gekennzeichnet daß die optischen Quellen Laser sind.

6. Netzwerk nach einem der Ansprüche 2 bis 5, dadurch gekennzeichnet, daß alle Modulatoren des Netzwerks, die mit einer optischen Quelle einer gegebenen Wellenlänge gekoppelt sind, in einer jeweiligen unterschiedlichen Einheit ($U_1 - U_{100}$) untergebracht sind.

7. Netzwerk nach Anspruch 6, dadurch gekennzeichnet, daß die Anzahl von Modulatoren in jeder Einheit gleich der Anzahl von optischen Multiplexsignalen ist, die durch jene Einheit erzeugt sind.

8. Netzwerk nach einem der Ansprüche 2 bis 5, dadurch gekennzeichnet, daß alle Modulatoren des Netzwerks, deren optische Ausgänge einen Teil der gleichen Multiplexeinrichtung bilden, in einer jeweiligen unterschiedlichen Einheit untergebracht sind.

9. Netzwerk nach Anspruch 8, dadurch gekenn-



zeichnet, daß die Anzahl von Einheiten gleich der Anzahl von unterschiedlichen Wellenlängen von den optischen Quellen ist.

10. Netzwerk nach einem der Ansprüche 6 bis 9, dadurch gekennzeichnet, daß die Modulatoren jeder Einheit auf einem einzigen Lithiumniobat-substrat gebildet sind. 5
11. Netzwerk nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß die optische Umschalteneinrichtung eine Vielzahl optischer Raumschalter enthält, von denen jeder einen Eingang aufweist, der mit einer jeweiligen Multiplexeinrichtung optisch gekoppelt ist und eine Vielzahl von Ausgängen, wobei ein jeweiliger Demultiplexer mit jedem Ausgang jedes optischen Raumschalters optisch gekoppelt ist. 10
12. Netzwerk nach einem der Ansprüche 1 bis 10, dadurch gekennzeichnet, daß die optische Umschalteneinrichtung eine Vielzahl optischer Raumschalter enthält, wobei jeder eine Vielzahl von Eingängen aufweist, wobei jede Multiplexeinrichtung mit einem Eingang jedes optischen Raumschalters optisch gekoppelt ist, und wobei jeder eine Vielzahl von Ausgängen aufweist, wobei ein jeweiliger Demultiplexer mit jedem Ausgang jedes optischen Raumschalters optisch gekoppelt ist. 15 20
13. Netzwerk nach Anspruch 12, dadurch gekennzeichnet, daß die Anzahl von Ausgängen jedes optischen Raumschalters gleich der Anzahl von Multiplexeinrichtungen ist. 25 30
14. Netzwerk nach Anspruch 13, wenn er von Anspruch 9 abhängt, dadurch gekennzeichnet, daß jeder optische Kombinator ein Sternkople mit einer Vielzahl von Ausgängen ist, wobei jeder Ausgang mit einem Eingang eines unterschiedlichen optischen Raumschalters optisch gekoppelt ist. 35 40
15. Netzwerk nach einem der Ansprüche 1 bis 14, dadurch gekennzeichnet, daß jeder Demultiplexer auch mit irgendeiner optischen Quelle koppelbar ist und zwar durch eine Auswahlrichtung, die auf ein Auswahlsignal antwortet. 45 50
16. Netzwerk nach einem der Ansprüche 14 und 15, wenn sie von Anspruch 13 abhängen, dadurch gekennzeichnet, daß die Auswahlrichtung eine Vielzahl zweiter optischer Raumschalter umfaßt, die anzahlmäßig gleich der Anzahl der optischen Raumschalter sind, wobei jeder eine Vielzahl von Eingängen aufweist, die anzahlmäßig gleich der Anzahl unter-

schiedlicher Wellenlängen der optischen Quellen sind, und wobei jeder Eingang mit einer optischen Quelle einer unterschiedlichen Wellenlänge verbunden ist und wobei jeder eine Vielzahl von Ausgängen aufweist, die anzahlmäßig gleich der Anzahl der optischen Raumschalter sind, wobei jeder Ausgang eines gegebenen zweiten optischen Raumschalters mit einem unterschiedlichen Ausgang eines entsprechenden optischen Raumschalters kombiniert ist.

17. Netzwerk nach einem der Ansprüche 15 bis 16, dadurch gekennzeichnet, daß jeder zweite optische Raumschalter einen Teil des entsprechenden optischen Raumschalters bildet, wobei jeder Ausgang des optischen Raumschalters gleichzeitig mit einem der Eingänge optisch koppelbar ist, die mit einer Multiplexeinrichtung verbunden sind. 15
18. Netzwerk nach einem der Ansprüche 15 bis 16, und zwar zur Verwendung bei einem Heterodynempfänger, dadurch gekennzeichnet, daß die Auswahlrichtung eine Frequenzverschiebeeinrichtung enthält, wodurch jede optische Quelle um einen vorbestimmten Betrag frequenzverschoben wird, bevor sie mit dem Ausgang eines optischen Raumschalters gekoppelt wird. 20
19. Netzwerk nach Anspruch 2, dadurch gekennzeichnet, daß der Empfänger ein einstellbares Filter enthält, das auf ein Auswahlsignal antwortet, um nur einer der Wellenlängen des Wellenlängenmultiplexes zu erlauben, den optischen Detektor des Empfängers zu erreichen. 25 30

Revendications

1. Réseau optique commuté pour transmettre des signaux de l'une quelconque d'une pluralité de stations émettrices ($T_1 - T_{10000}$) à l'une quelconque d'une pluralité de stations réceptrices ($R_1 - R_{10000}$), comprenant:
au moins deux moyens de multiplexage optique ($U_1 - U_{100}$) réagissant chacun à des signaux provenant de deux ou davantage de stations émettrices respectives et délivrant chacun un signal multiplex optique correspondant aux signaux des stations émettrices auxquelles il est connecté;
une pluralité de moyens de démultiplexage (14);
et une pluralité de moyens de commutation optique ($SW_1 - SW_{100}$);
caractérisé en ce que
la pluralité de moyens de commutation



optique est agencée pour recevoir tous les signaux multiplex optiques et chaque moyen de commutation optique est connecté à deux ou davantage de récepteurs respectifs, chaque moyen de commutation optique étant com-

mandé pour commuter des signaux multiplex optiques sélectionnés à des récepteurs sélectionnés,
un moyen de démultiplexage respectif étant connecté à chaque sortie (OP) de chaque moyen de commutation optique, chaque moyen de démultiplexage, correspondant à un récepteur unique, étant commandé pour démultiplexer le signal multiplexé sélectionné par le moyen de commutation optique et pour envoyer au récepteur un signal sélectionné dans le signal démultiplexé.

2. Réseau selon la revendication 1, caractérisé en ce que chaque moyen de multiplexage comporte une pluralité de sources optiques ($O_1 - O_{100}$) pour fournir de l'énergie optique à deux ou davantage de longueurs d'onde, une pluralité de modulateurs ($M_1 - M_{100}$) qui sont chacun couplés optiquement à une source optique respective et réagissent à un signal provenant d'une station émettrice respective pour délivrer un signal optique représentatif de ce signal de la station émettrice, ainsi qu'un moyen de combinaison optique (C1) pour combiner les signaux optiques afin de former le multiplex optique.
3. Réseau selon la revendication 1, caractérisé en ce qu'il y a seulement une source optique d'énergie optique à chaque longueur d'onde.
4. Réseau selon la revendication 2 ou 3, caractérisé en ce que les longueurs d'onde des sources optiques sont fixées par un moyen central de référence de longueur d'onde (12).
5. Réseau selon l'une quelconque des revendications 2 à 4, caractérisé en ce que les sources optiques sont des lasers.
6. Réseau selon l'une quelconque des revendications 2 à 5, caractérisé en ce que tous les modulateurs du réseau couplés à une source optique d'une longueur d'onde donnée sont logés dans une unité distincte respective ($U_1 - U_{100}$).
7. Réseau selon la revendication 6, caractérisé en ce que le nombre de modulateurs dans chaque unité est égal au nombre de signaux multiplex optiques délivrés par cette unité.

8. Réseau selon l'une quelconque des revendications 2 à 5, caractérisé en ce que tous les modulateurs du réseau dont les sorties optiques font partie du même moyen de multiplexage sont logés dans une unité distincte respective.

9. Réseau selon la revendication 8, caractérisé en ce que le nombre d'unités est égal au nombre de longueurs d'onde distinctes des sources optiques.

10. Réseau selon l'une quelconque des revendications 6 à 9, caractérisé en ce que les modulateurs de chaque unité sont formés sur un seul substrat en niobate de lithium.

11. Réseau selon l'une quelconque des revendications précédentes, caractérisé en ce que le moyen de commutation optique comporte une pluralité de commutateurs spatiaux optiques, possédant chacun une entrée couplée optiquement à un moyen de multiplexage respectif et une pluralité de sorties, un démultiplexeur respectif étant couplé optiquement à chaque sortie de chaque commutateur spatial optique.

12. Réseau selon l'une quelconque des revendications 1 à 10, caractérisé en ce que le moyen de commutation optique comporte une pluralité de commutateurs spatiaux optiques, possédant chacun une pluralité d'entrées, chaque moyen de multiplexage étant couplé optiquement à une entrée de chaque commutateur spatial optique et chaque commutateur possédant une pluralité de sorties, un démultiplexeur respectif étant couplé optiquement à chaque sortie de chaque commutateur spatial optique.

13. Réseau selon la revendication 12, caractérisé en ce que le nombre de sorties de chaque commutateur spatial optique est égal au nombre de moyens de multiplexage.

14. Réseau selon la revendication 13 dépendante de la revendication 9, caractérisé en ce que chaque combineur optique est un coupleur en étoile ayant une pluralité de sorties, chaque sortie étant couplée optiquement à une entrée d'un commutateur spatial optique distinct.

15. Réseau selon l'une quelconque des revendications 1 à 14, caractérisé en ce que chaque démultiplexeur est également couplable à n'importe quelle source optique par un moyen de sélection réagissant à un signal de sélection.



16. Réseau selon la revendication 14 ou 15 dépendante de la revendication 13, caractérisé en ce que le moyen de sélection comprend une pluralité de commutateurs spatiaux optiques secondaires dont le nombre est égal au nombre de commutateurs spatiaux optiques et qui possèdent chacun une pluralité d'entrées dont le nombre est égal au nombre de longueurs d'onde distinctes des sources optiques, chaque entrée étant connectée à une source optique de longueur d'onde distincte, de même qu'une pluralité de sorties dont le nombre est égal au nombre de commutateurs spatiaux optiques, chaque sortie d'un commutateur spatial optique secondaire donné étant combinée avec une sortie distincte d'un commutateur spatial optique correspondant.
17. Réseau selon la revendication 15 ou 16, caractérisé en ce que chaque commutateur spatial optique secondaire fait partie du commutateur spatial optique correspondant, chaque sortie du commutateur spatial optique étant optiquement couplable simultanément à l'une des entrées connectées à un moyen de multiplexage.
18. Réseau selon la revendication 15 ou 16 et destiné à être utilisé avec un récepteur hétérodyne, caractérisé en ce que le moyen de sélection comporte un moyen de décalage de fréquence, l'agencement étant tel que chaque source optique est décalée en fréquence d'une quantité prédéterminée avant d'être couplée à la sortie d'un commutateur spatial optique.
19. Réseau selon la revendication 2, caractérisé en ce que le récepteur comporte un filtre accordable réagissant à un signal de sélection afin de permettre à seulement l'une des longueurs d'onde du multiplex de longueur d'onde d'atteindre le détecteur optique du récepteur.

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